

REPORT DOCUMENTATION PAGE

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14. ABSTRACT Direct new technical developments are reported in the following sections with respect to the last report. We have been focused to prepare the system for evaluation on the SWRI Test site. In order to be able to perform as much testing as possible we have worked on 2 main aspects: Software: New behaviors have been implemented that allow the system to overcome more and difficult obstacles. A behavior to attach to branches and similar structures has been implemented. (see figure 1) A behavior to a to slide on a branch, after having attached to it has been implemented. (see figure 1) (See Attached)					
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A behavior to push pull with front and hind legs while holding on to a branch or similar structure has been implemented to over come very wide ditches (multiple meters) with a tree or similar structure as a bridge. A behavior to lay down/stretch out the front legs has been implemented to overcome small ditches that are wider than the robot is long and with no structural features (like natural bridge). A roll over behavior has been implemented. This behavior becomes active if the system is laying on its back. Instead of rolling around it will simply continue to walk on its back by inversing the direction of its legs. A behavior has been implanted to use on of the 8 legs to grab objects (e.g. a wooden bar) and to carry it away by using only 7 Legs. A behavior has been implanted to compensate for a missing or other wise used leg (other than walking).

Hardware:

Plug and Play legs have been further developed to be changed by simply loosening 2 screw. The software recognizes the replacement leg autonomously and adjusts the new leg automatically. Battery replacement can be done on-line by plugging in the cord. The system will then continue to work. Advantage of this approach is: no turning off of the system and restarting after the battery replacement. A Scanning (left right movement of aprox. 45 degrees) Ultrasound sensor has been integrated in the front of the system for obstacle detection/avoidance.

FINAL PROGRESS REPORT

TO: DR. ALAN RUDOLPH, DARPA/DSO, ARLINGTON, VA, USA

FROM: DR. FRANK KIRCHNER, GMD, BONN, GERMANY

PROJECT: TERRESTRIAL AMUBULATORY ROBOTS

GRANT: N00014-99-1-0483

DATE: JUNE 2003.

1. EXECUTIVE SUMMARY

The focus the final report is the final project evaluation in Texas San Antonio, August 2002.

2. TECHNICAL PROGRESS

Direct new technical developments are reported in the following sections with respect to the last report. We have been focused to prepare the system for evaluation on the SWRI Test site. In order to be able to perform as much testing as possible we have worked on 2 main aspects:

1) Software:

- a. New behaviours have been implemented that allow the system to overcome more and difficult obstacles.
 - i. A behaviour to attach to branches and similar structures has been implemented (see figure 1)
 - ii. A behaviour to slide on a branch, after having attached to it has been implemented (see figure 1)

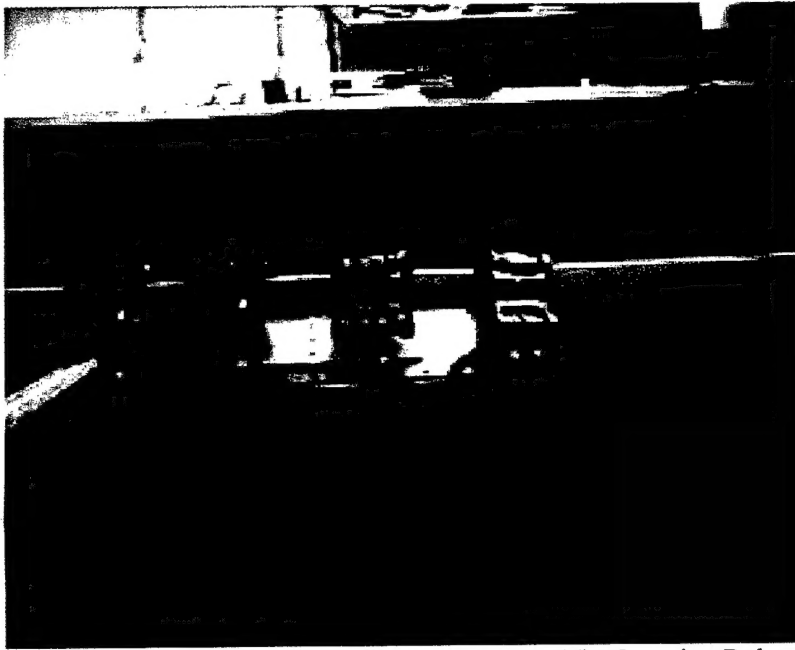


Figure 1: The Scorpion Robot attaching to a structure and then using the structure to overcome a ditch by sliding on the structure.

- iii. A behaviour to push pull with front and hind legs while holding on to a branch or similar structure has been implemented to over come very wide ditches (multiple meters) with a tree or similar structure as a bridge. (figure 2)

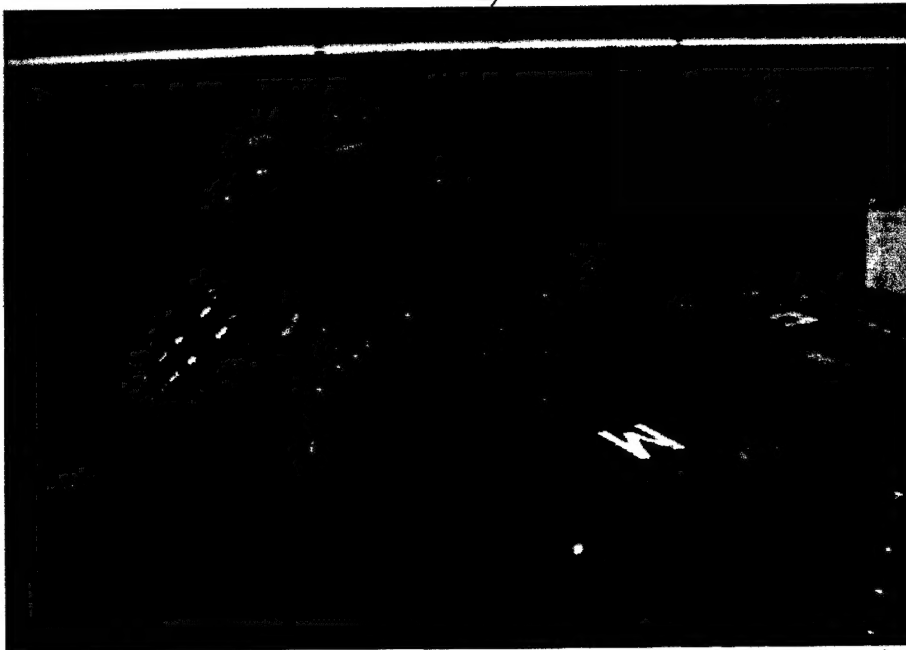


Figure 2: The Scorpion using its fron/hind legs to pull/push to overcome a natural bridge over a ditch.

- iv. A behaviour to lay down/ stretch out the front legs has been implemented to overcome small ditches that are wider than the robot is long and with no structural features (like natural bridge).

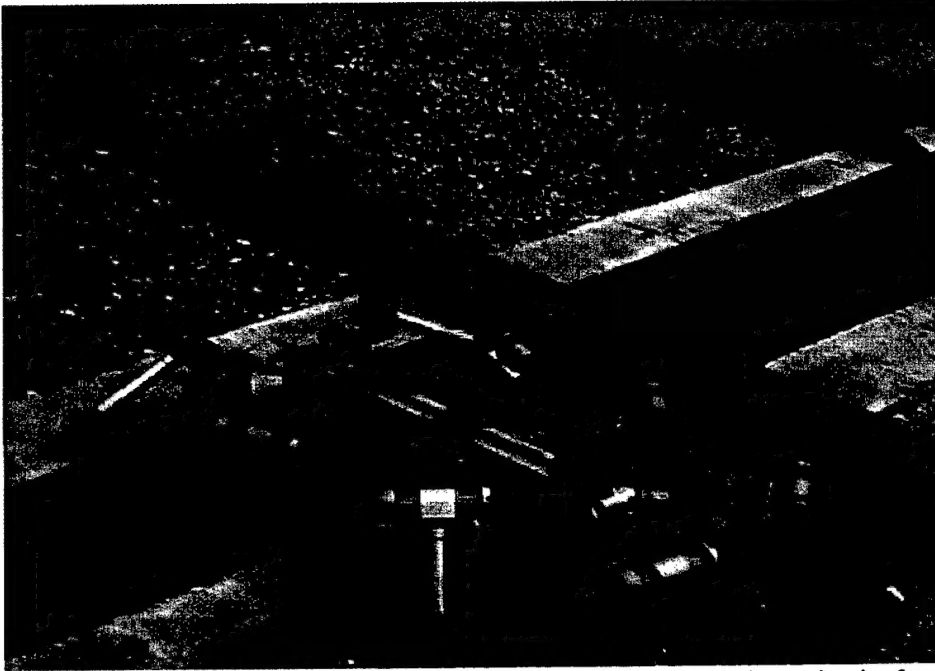


Figure 3: The Scorpion robot using its front legs to overcome ditches without structural features like natural bridge.

- v. A roll over behaviour has been implemented. This behaviour becomes active if the system is laying on its back. Instead of rolling around it will simply continue to walk on its back by inversing the direction of its legs.



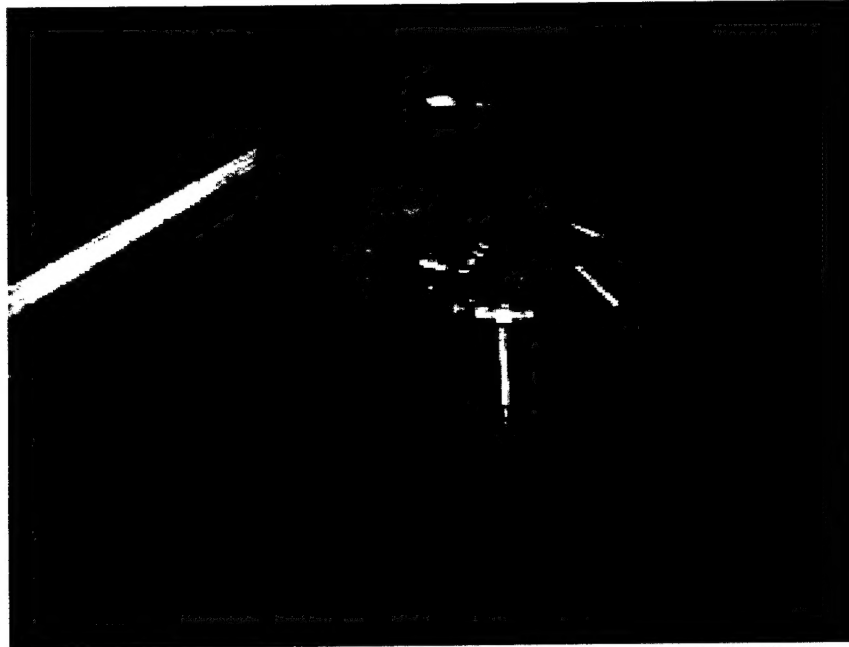


Figure 4/5: The Scorpion robot inverting the direction of its legs after having toppled over and laying on its back. It can then continue to walk/operate normally.

- vi. A behaviour has been implanted to use one of the 8 legs to grab objects (e.g. a wooden bar) and to carry it away by using only 7 legs for walking.

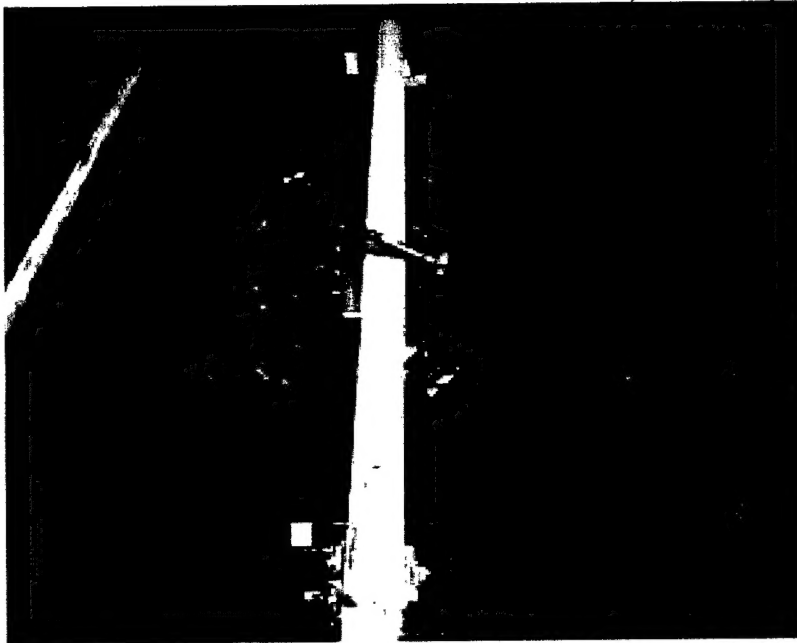


Figure 6: The Scorpion Robot grabbing a board (4.5. kg)

- vii. A behaviour has been implemented to compensate for a missing or

otherwise used leg (other than walking).

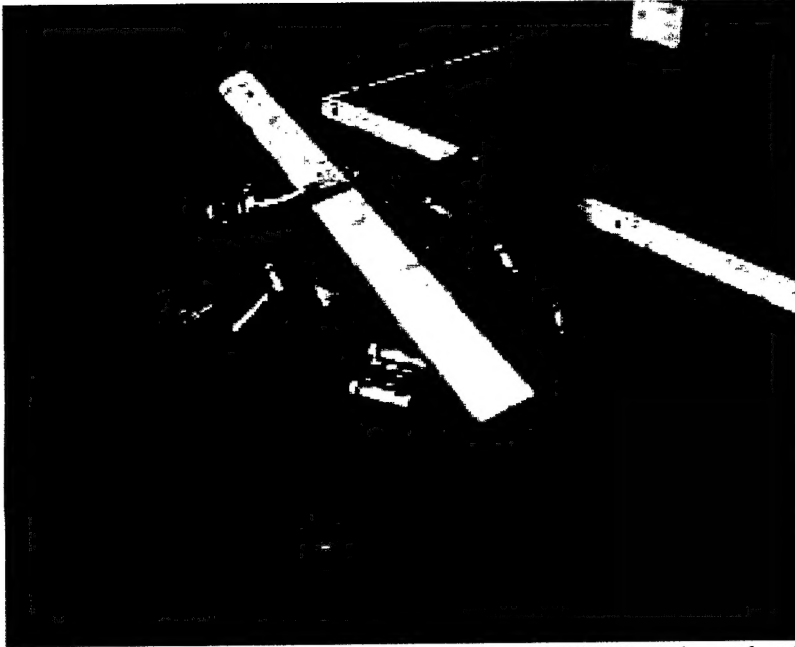


Figure 7: The Scorpion robot holding a board (2.5 kg) while walking over an obstacles (height of the obstacle 25cm).

2) Hardware:

- a. Plug and Play legs have been further developed to be changed by simply loosening 2 screws. The software recognizes the replacement leg autonomously and adjusts the new leg automatically.
- b. Battery replacement can be done on-line by plugging in the power cord, changing the battery pack and unplugging the power cord. The system will then continue to work. Advantage of this approach is: no turning off of the system and restarting after battery replacement
- c. A scanning (left right movement of aprox. 45 degrees) Ultrasound sensor has been integrated in the front of the system for obstacle detection/avoidance.



Figure 8: The Scorpion scanning Ultrasound sensor in the front of the system.

3. MILESTONE REPORT

Milestones as according to the original proposal have been achieved as reported in last progress report.

4. FUTURE ISSUES & TECHNOLOGY TRANSFER

We have submitted a 9 months proposal to NASA-Ames research center to continue working on joint robotic activities involving the Scorpion and NASA's 'K9' rover system. Initial response is positive but grant has not yet been awarded. No feedback has been received so far. We plan to submit a new proposal for the continuation of testing of the current scorpion robot by the end of 2003 or beginning of 2004 to Dr. Alan Rudolph.